Response of planar silicon sensors to extreme doses

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Purpose

Find out the upper limit at which planar sensor can be used in severe hadron radiation environment. This is intended for minimum ionising particle position measurements and only measures the signal, because the noise and threshold settings for the individual detectors depend on each particular geometry and electronics. But knowing your expected signal is quite of an important step…..

Irradiations

Irradiation and dosimetry:

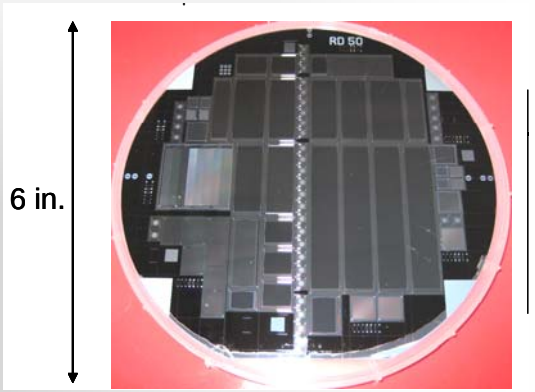
Neutron:
TRIGA Mark II research reactor
Reactor Centre of the
Jozef Stefan Institute, Ljubljana, Slovenia

24GeV protons:
CERN-PS Irrad1 (M. Glaser)

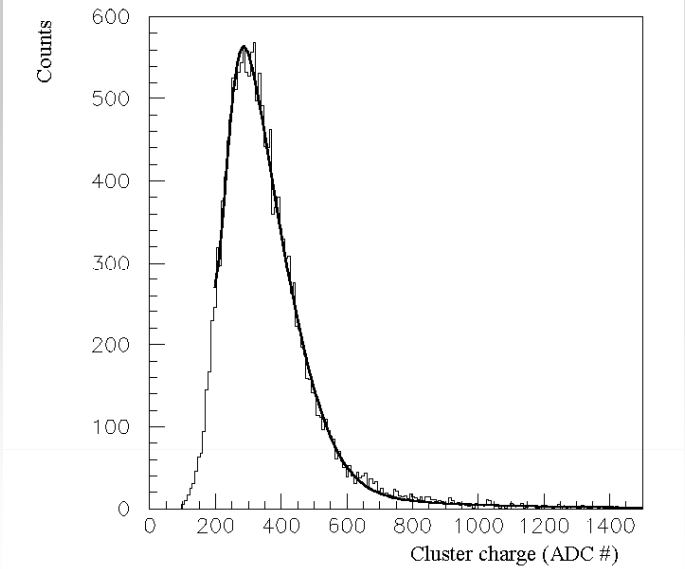
26 MeV protons:
Compact Cyclotron of the University of Karlsruhe (W. de Boer, A. Dierlamm)

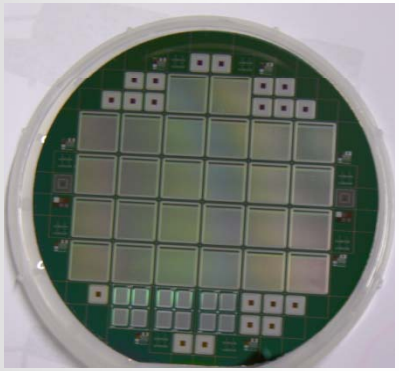
Devices, set-up and method

4” *RD50* mask, Micron processing, 140µm and 300µm, p-type
6” *RD50* mask, Micron processing, 300µm n-in-n
6” *LHCb* mask, Micron processing, 200µm and 300µm n-in-n
All sensors 1x1cm^2, 128 strips, all attached to 40MHz sct128, analogue readout, **-25^{o}C measurements** in freezer, large mass copper cooling block cooled by air blowing.



Most probable value from the energy spectrum of a ^{90}Sr radioactive source

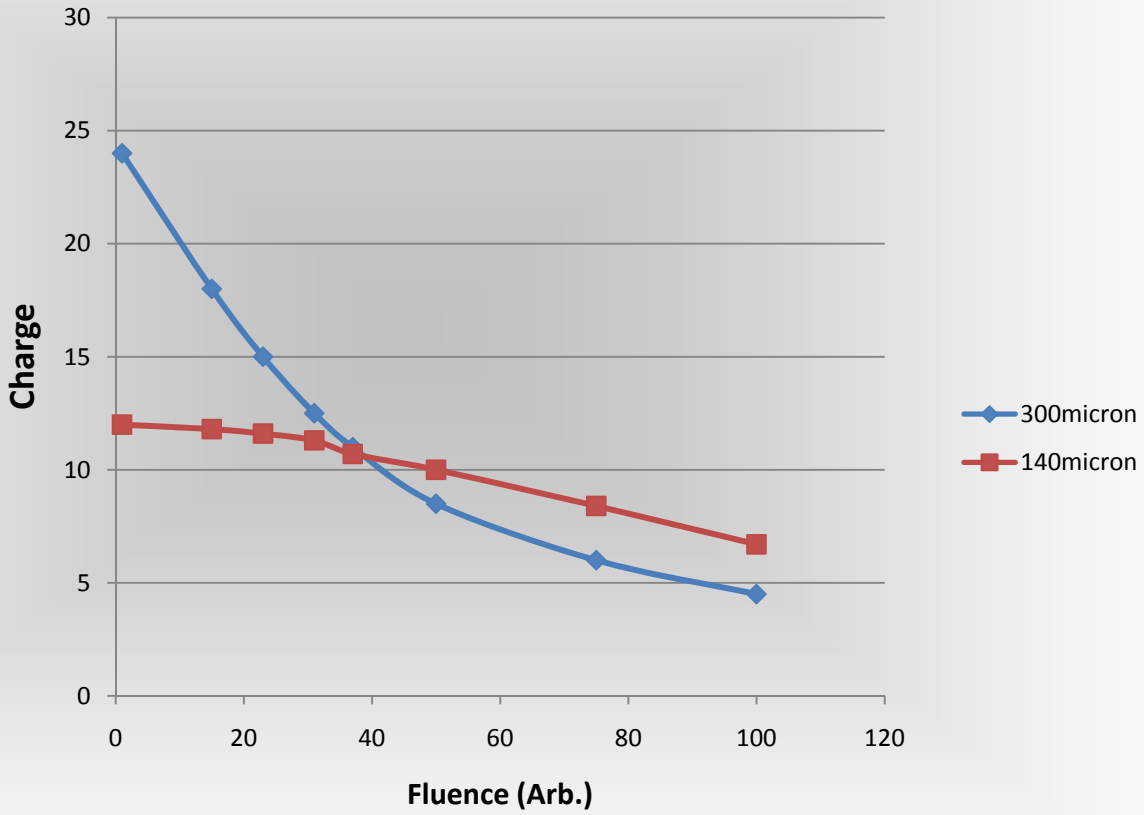




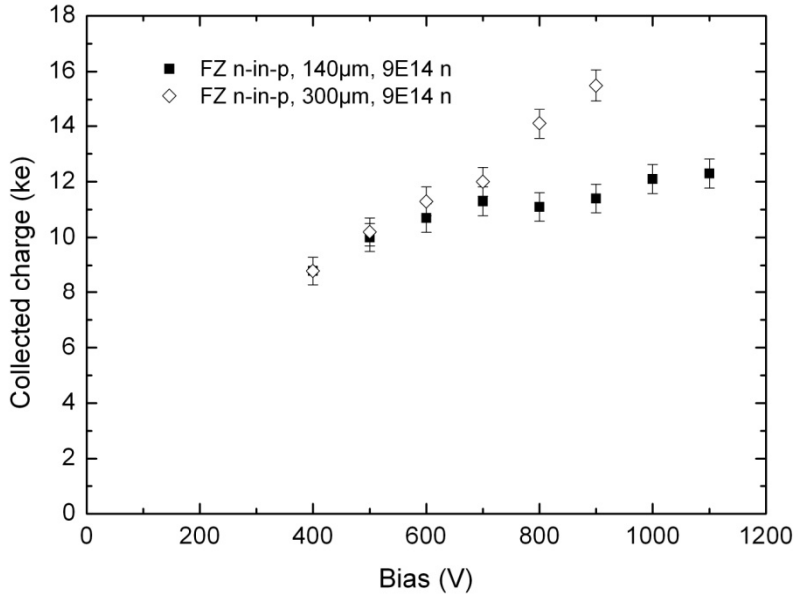
Effect of thickness?

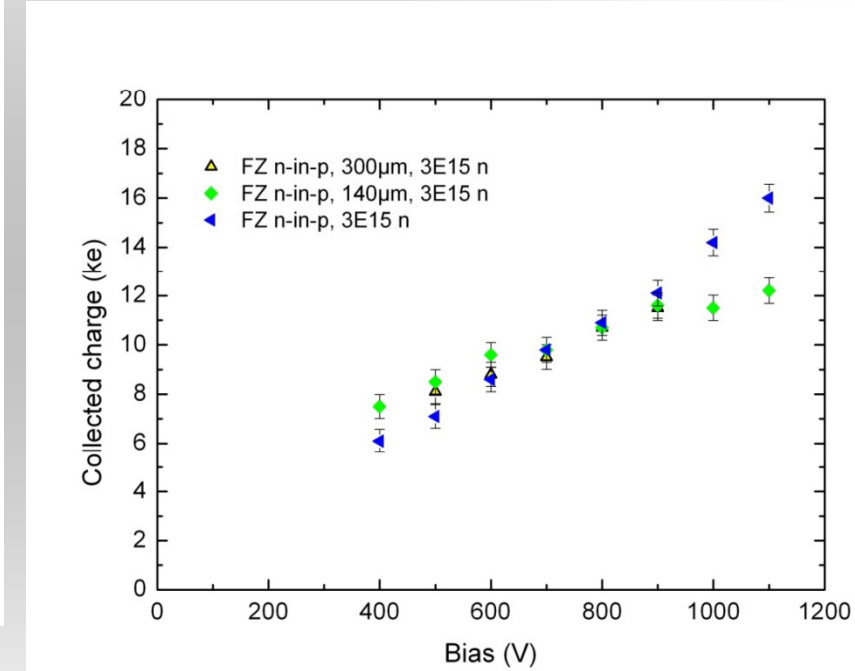
Is there an advantage of going thin at high fluences?

Does this happen, and at what fluence?

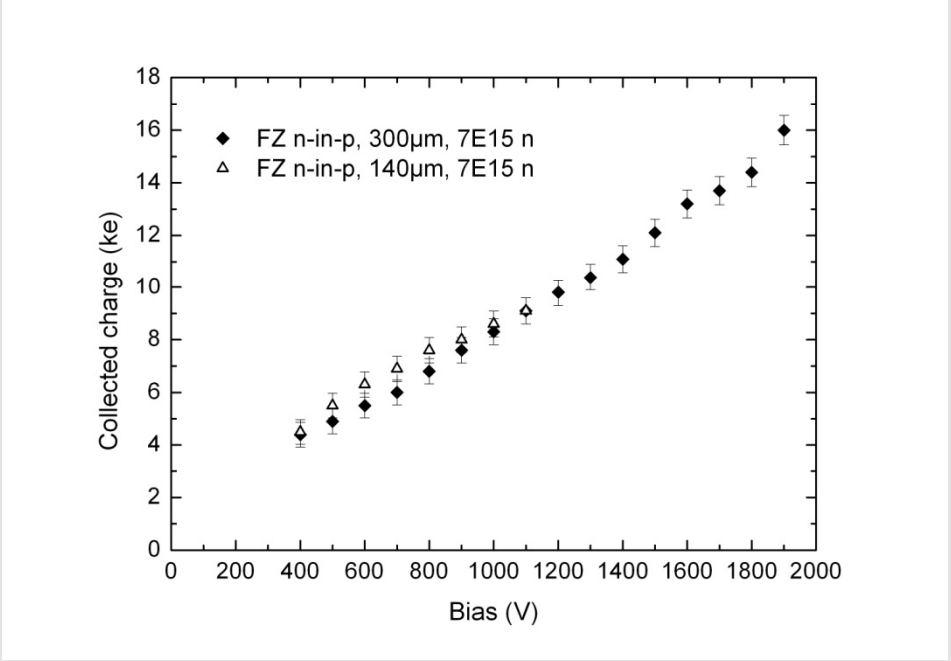


Response of 140µm and 300µm after 1 and 3x10^{15} n cm^{-2}

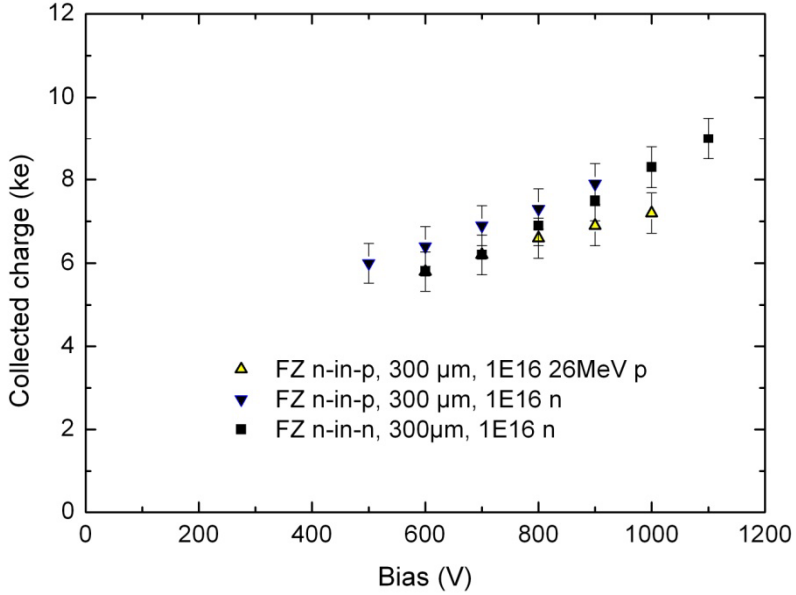




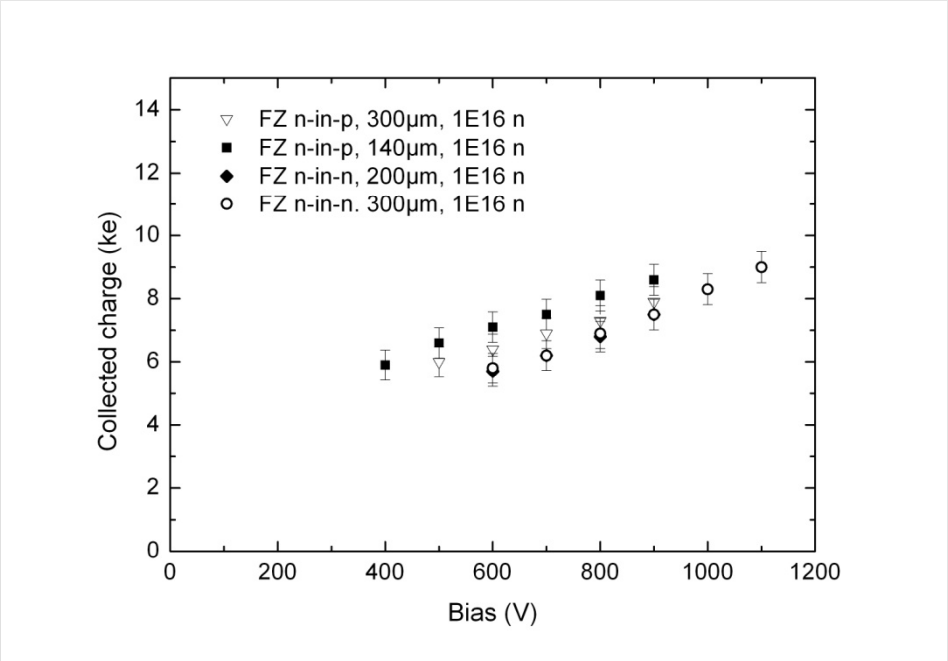
Response of 140µm and 300µm after 7E15 n cm^{-2}



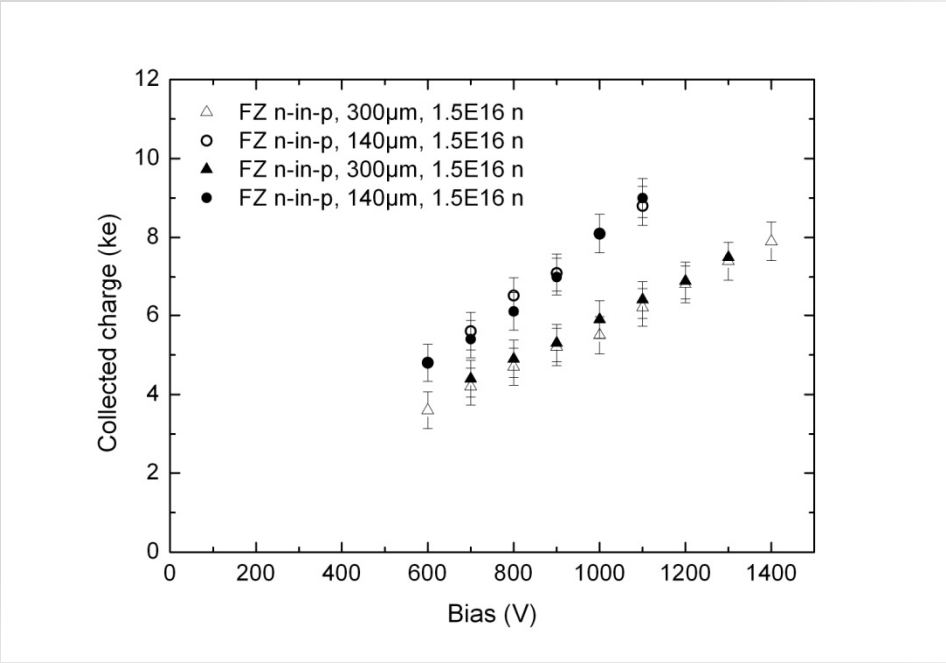
Response of 300µm after 1E16 n_{eq} cm^{-2} (26MeV and reactor neutron irradiations)



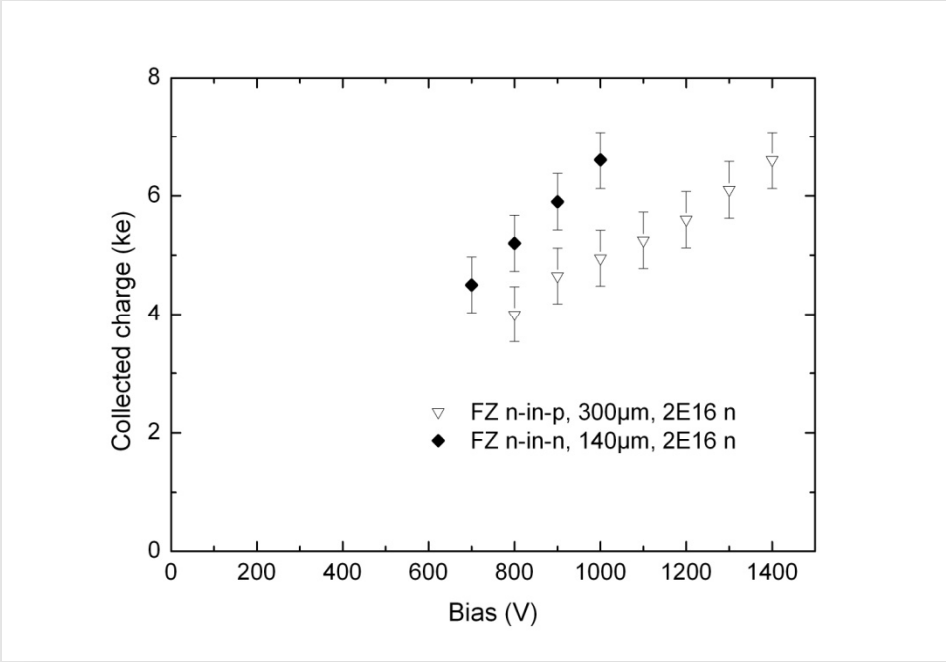
Response of 140µm and 300µm after 1E16 n cm^{-2}



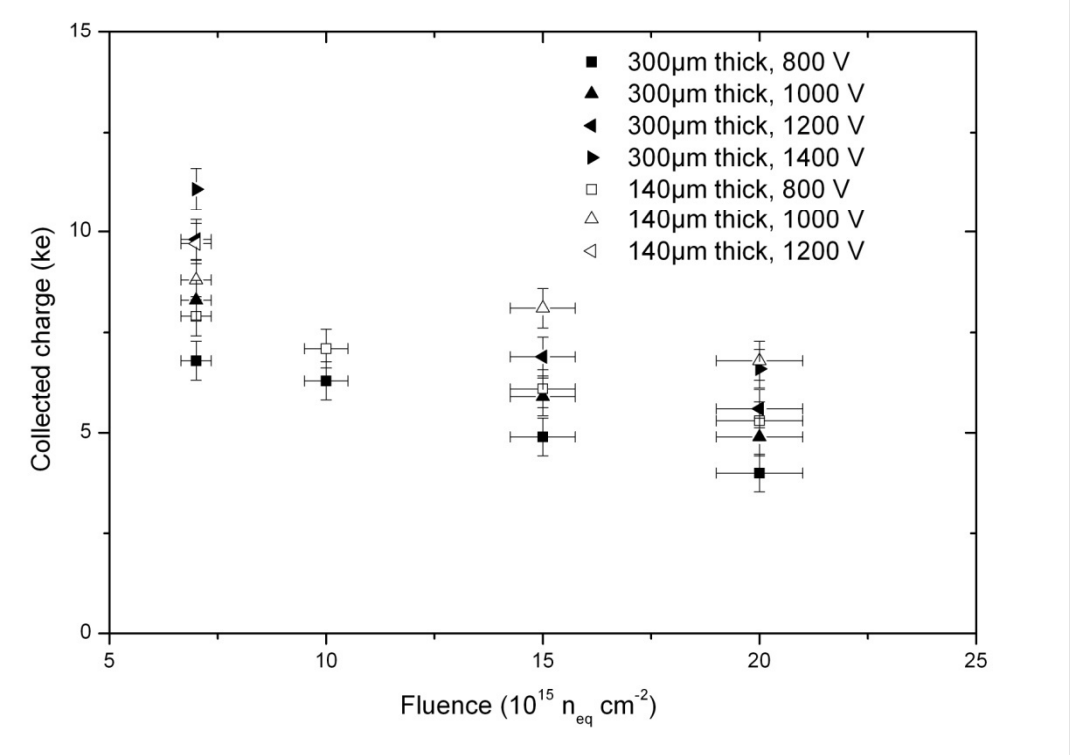
Response of 140µm and 300µm after 1.5E16 n cm^{-2}



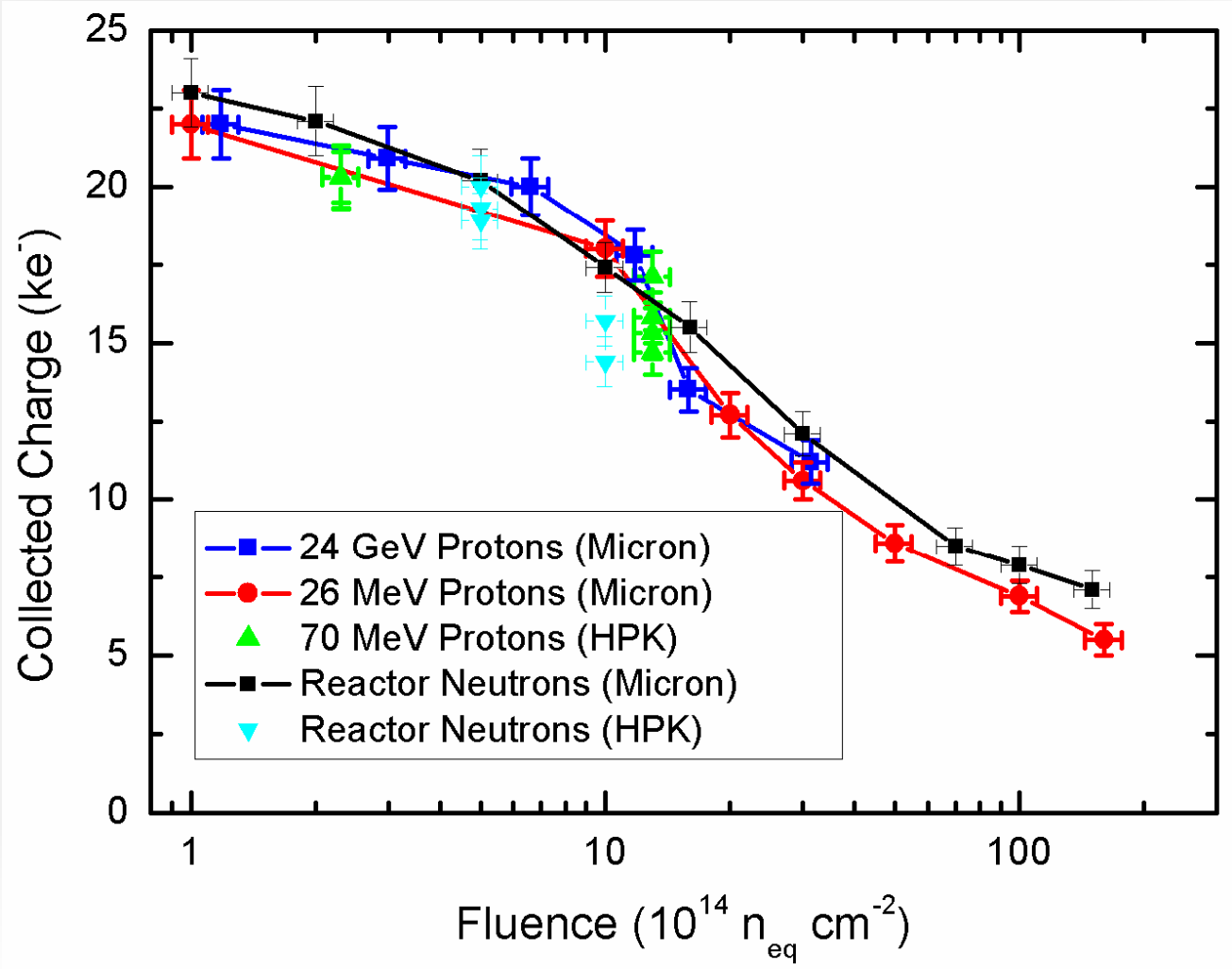
Response of 140µm and 300µm after 2E16 n cm^{-2}



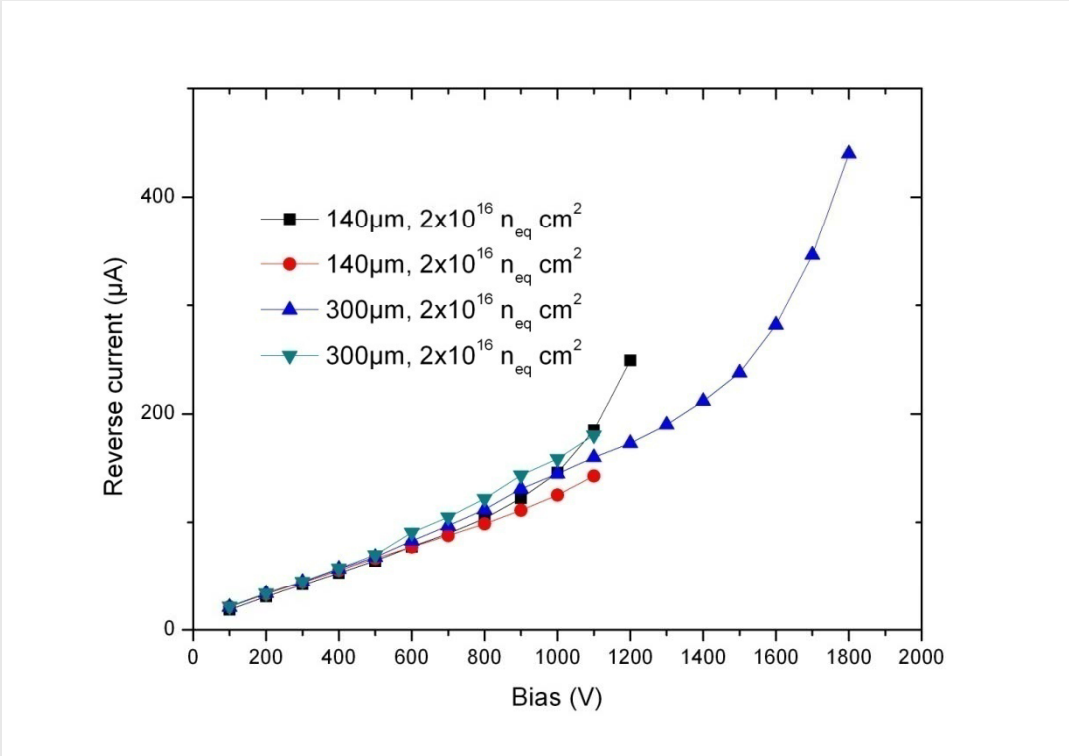
Super-high neutron doses summary, thin and thick



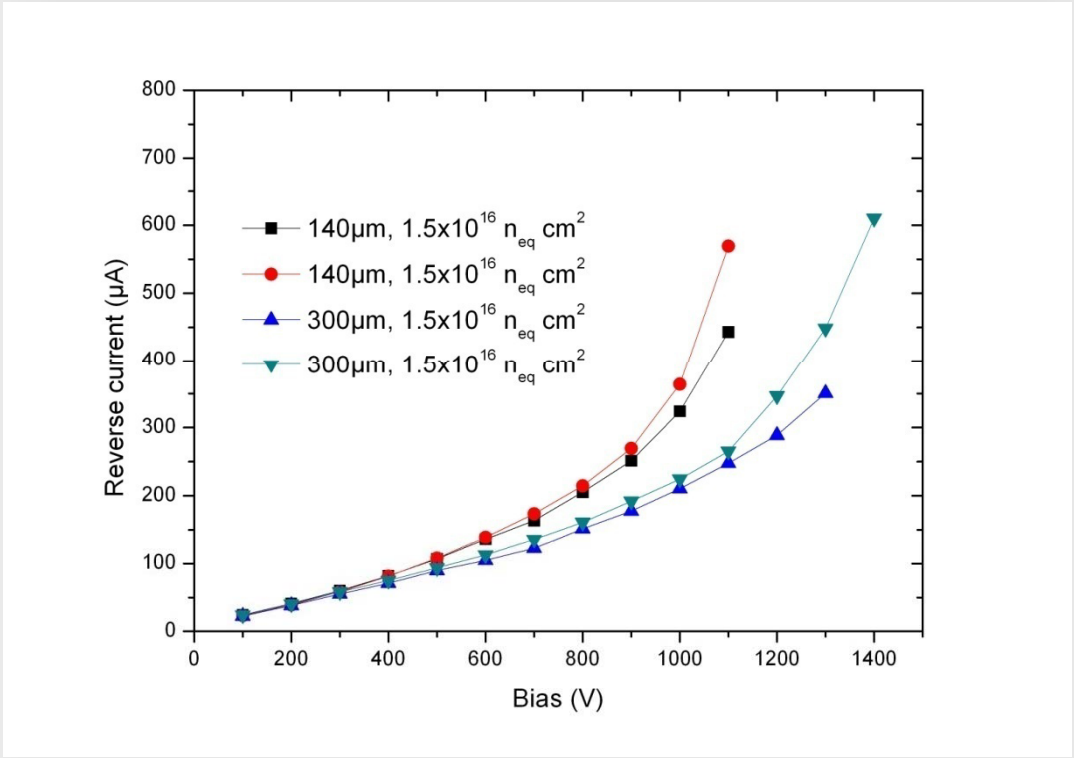
Comparison neutrons and protons



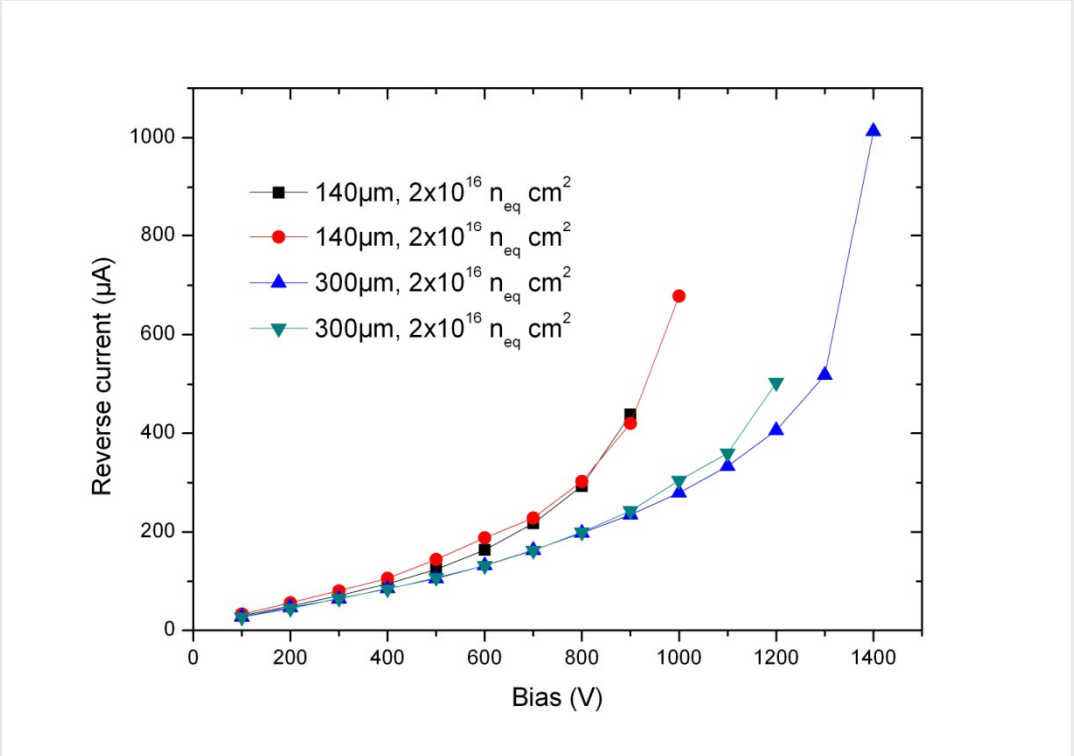
Reverse current (at -25°C) of thin and thick sensors after 7E15 n cm^{-2}



Reverse current (at -25°C) of thin and thick sensors after 1.5E16 n cm^{-2}

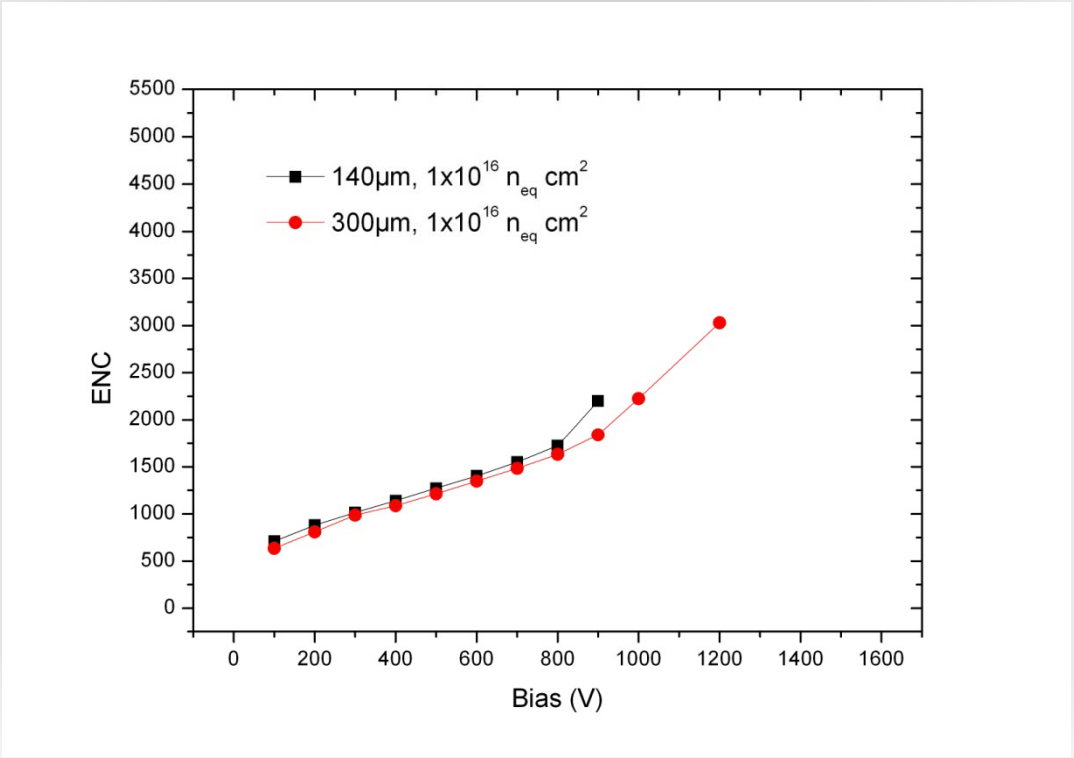


Reverse current (at -25°C) of thin and thick sensors after 2E16 n cm^{-2}



Issues with the high currents: thermal runway and shot noise

SHOT NOISE



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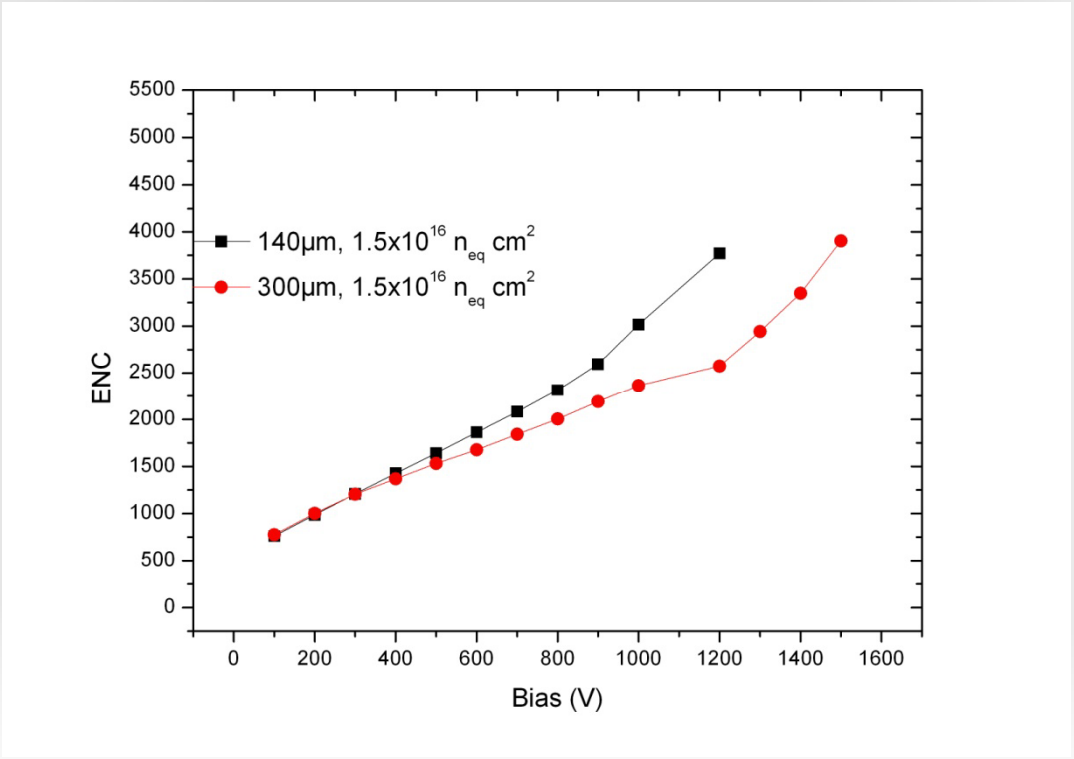

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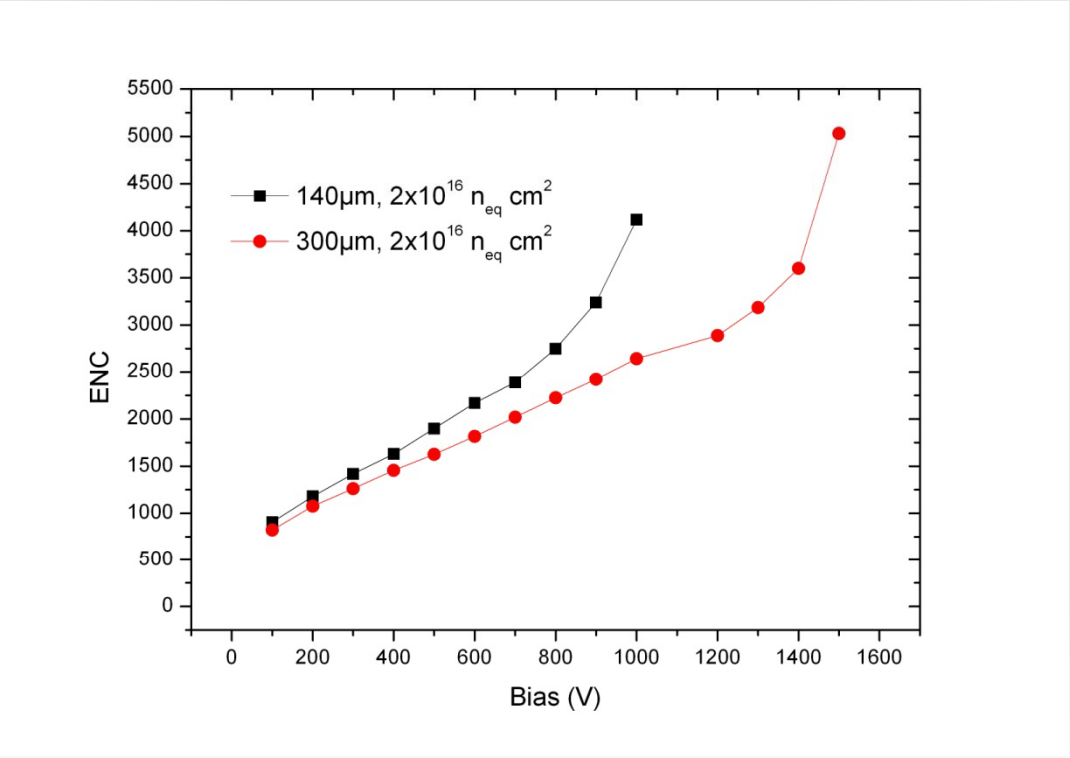

Future work:

- Measure extremely high doses after proton irradiations (partially done).
- Measure the annealing of the CCE and current properties after these extreme doses
- Measure the charge sharing and CCE properties of *pixel geometry* sensors.